4.1.6. ATMOSPHERIC WATER VAPOR

Water vapor measurements with balloonborne frost-point hygrometers continued at Boulder, Colorado. In addition water vapor soundings were made at Kiruna, Sweden, during January and March 2000 as part of the SAGE III (Stratospheric Aerosol and Gas Experiment) Ozone Loss and Validation Experiment (SOLVE) campaign. The long-term record of stratospheric water vapor measurements at Boulder [*Oltmans et al.*, 2000] through 2001 has been analyzed with the technique described by *Harris et al.* [2001]. The technique is also briefly described in section 4.2.3. The autoregressive model was modified for water vapor to include only the seasonal cycle as an explanatory variable. The residuals from the model with the long-term variation added back (Figure 4.9) have been fitted after the data were filtered in the frequency domain to produce a tendency curve. The changes in this tendency curve, found by dif-ferentiation, give the instantaneous growth rate curve (Figure 4.10). The growth rate shows relatively large year-to-year variations, including periods of significant negative growth, but the average growth rate has been positive. The deviations of approximately ±0.5 ppmv are around an average water vapor mixing ratio of about 4 ppmv. The largest positive excursions in the growth rate (1982, 1987, 1992, and 1997) occur several months prior to warm-phase El Niño/Southern Oscillation (ENSO) events. The average growth rate over the 20-yr observational record has been 0.04 ± 0.01 ppmv yr^{-1} or about 0.9% yr^{-1}. The increase in stratospheric water vapor at Boulder is confirmed by a number of other data sets including those from the Halogen Occultation Experiment (HALOE) instrument on the Upper Atmosphere Research Satellite (UARS) [*Rosenlof et al.*, 2001]. Several data sets predating the Boulder record also suggest that water vapor may have been increasing in the stratosphere for several decades [*Rosenlof et al.*, 2001].

During the winter of 1999-2000 the Third European Stratospheric Experiment on Ozone in 2000 (THESEO 2000) SOLVE campaign launched several water vapor soundings from Kiruna, Sweden. During two of the soundings (January and March 2000) multiple water-vapor-measuring instru-ments were flown in proximity in both space and time. On the flight of January 27, 2000, the Lyman-α hygrometer of the Forschungszentrum-Jülich and the cryogenic, chilled-mirror hygrometer of CMDL were flown within 2 hours of each other. The results agreed very closely in both absolute amount (differences <5%) and replication of small structural features in the profile [*Schiller et al.*, 2002].

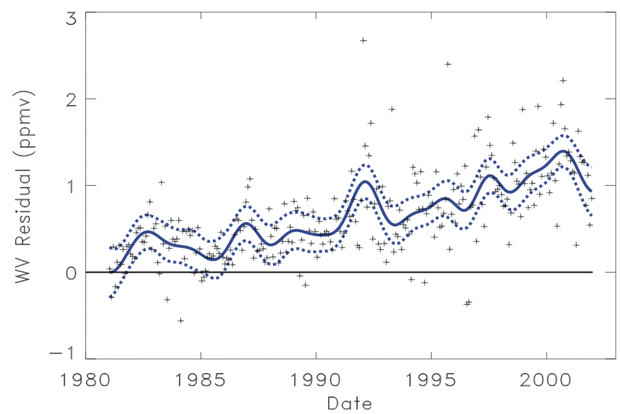

Fig. 4.9. Water vapor mixing ratio residuals (+) for the 16-24 km layer over Boulder, Colorado. The solid curve is a fit to the filtered monthly residuals. The dashed curves represent the 95% confidence interval based on the application of a Monte Carlo technique.

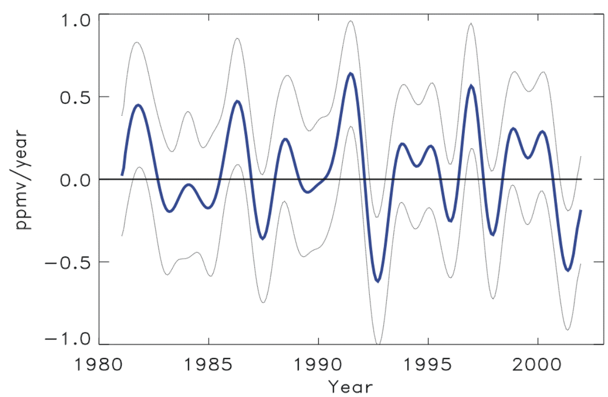

Fig. 4.10. The instantaneous (monthly) growth rate of water vapor (solid curve) in the 16-24 km layer over Boulder, Colorado. The dashed curves give the 95% confidence interval of the growth rate.